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Dry gas cleaning system for cupola : From concept to commissioning - A case study

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ABSTRACT

Most of the foundries in India are coke-based. They are usually besieged with pollution control problems. Normal stack emission from cupolas ranges from 1000 to 2500 mg/Nm³ of Suspended Particulate Materials (SPM) which is much higher than the acceptable limit of 150 mg/Nm³ fixed by Central Pollution Control Board (CPCB). National Metallurgical Laboratory (NML), which has considerable research experience in the development of dry gas cleaning system for cupolas was, in recent past, entrusted by Central Growth Works (Kulti), to study, design and install three number gas cleaning plants for six cupolas in their works. The project was successfully completed by NML and the SPM level attained was much below the CPCB Norm.

In this case study, the authors present the various aspects of the project, namely the design parameters, installation/ trial run/ commissioning activities etc towards achieving the desired SPM level.

Key Words *: Stack Emission, SPM level, Cupola, Gas Cleaning Plant.*

INTRODUCTION

The Indian Foundry Industry has contributed significantly for the development of our National economy. While giving due credit to the industry for its performance, it should be borne in mind that the same was achieved at the cost of environment pollution to a great extent. Most of the foundries in India are coke-based. Coke-based foundries are besieged with pollution control problems. Normal stack emission from foundries ranges from 1000 to 2500 mg/Nm³ of SPM. As per the directive of the Honourable Supreme Court of India, pollution has to be within the acceptable limit fixed by CPCB which specifies that the SPM level in the cupola emission must not be more than 150 mg/Nm³. As a result of this stringent standard, most of the foundries are facing an uncertain future. Many foundries have already shut down. More are facing closure.

NML'S ROLE TOWARDS POLLUTION- ABATEMENT IN COKE-BASED FOUNDRIES

In order to tackle the enormous socio-economic as well as technical problems towards abatement of pollution level in the coke-based foundries NML, Jamshedpur carried out considerable Research and Development work and developed a less capital-intensive and dry gas cleaning system of various modules and sizes capable of reducing the existing SPM level to the acceptable limit fixed by CPCB for cupolas that ranges from 2t/hr to 25t/hr capacities. Based on the design developed at NML some foundries of Howrah, West Bengal installed gas cleaning facilities in their cupolas and were successful in bringing down the SPM level to within the acceptable limit.

SPONSORED RESEARCH PROJECT-A CASE STUDY

The Central Growth Works (CGW) at Kulti, West Bengal has the distinction of having twelve cupolas which are the oldest and biggest in India. CGW sponsored a research project to NML to study, design and install three Gas Cleaning Plants (GCP) in their three shops each having two cupolas. The main task given to NML was to bring down the SPM content from the existing level of approx 1800 mg/Nm^3 to150mg/Nm^3.All the three GCPs have been commissioned within six months as per agreement requirement. The case study is based on this project.

DESIGN PARAMETERS

Appropriate basic data are essential for designing three numbers GCPs and these had to be correctly measured. A team of scientists from NML measured various design parameters such as flue gas quantity, temperature and emission level prior to the commencement of actual design work.

BASIC DESIGN DATA FOR A REPRESENTATIVE PLANT

i)	No of Cupolas	-	2
ii)	Capacity	-	14t/hr each
iii)	Dia ID	-	1.82m
iv)	Height	-	15.2m
v)	Flue Gas Rate	-	38000m^3/hr
vi)	Temperature	-	350°C
vii)	Dust Level	-	1800mg/Nm^3
viii)	Coke Consumption	-	2.5t/hr

PARTICLE SIZE ANALYSIS

Indicative particle size analysis of the flue dust of the cupolas is given as below in Table 1

Table 1 : Particle size analysis of flue dust

Size Range (microns)	%wt
>500	NIL
150-500	35
50-150	50
20-50	10
<20	5

SALIENT DESIGN FEATURES OF THE GAS CLEANING PLANT

I. Each gas cleaning plant caters to a specific shop containing two cupolas. The system is connected to both the cupolas in the shop. It is designed to handle the gases from one cupola at a time. (Ref Fig 1)

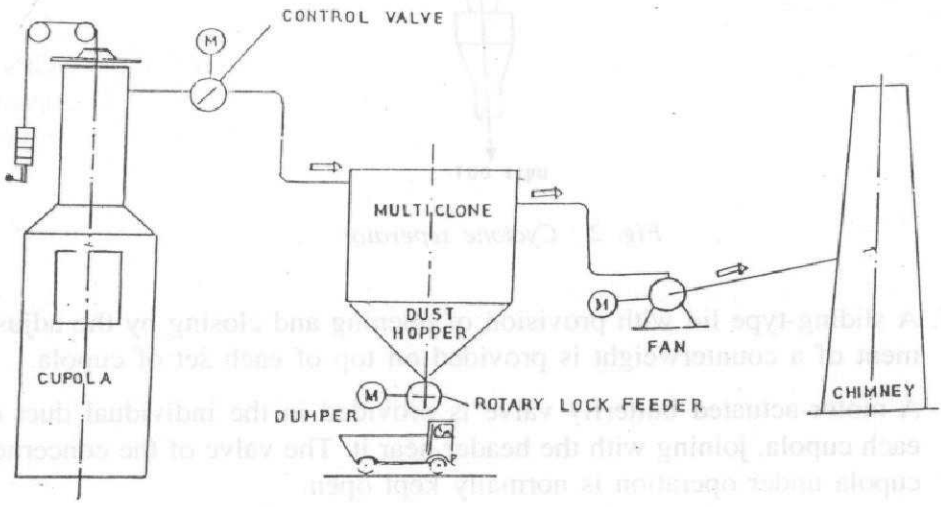

Fig. 1 : Dry gas cleaning plant

II. Flue gases at a high temperature from the cupola top enter the high performance cyclones. The resulting centrifugal action throws the dust outwards against the cyclone body in a descending helical path into an

airtight dust hopper. Cleaned gas forms an ascending vortex in the centre of the cyclone. (Ref Fig 2)

Optimum velocity of flue gas in ducting and cyclone - 15 to 22m/sec

Optimum velocity of flue gas in chimney—— 12 to 20m/sec

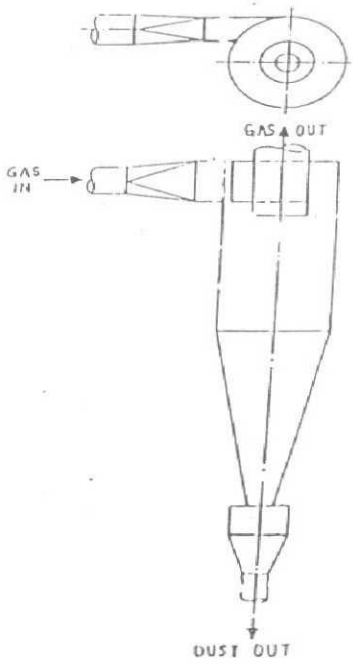

Fig. 2 : Cyclone seperator

III. A sliding-type lid with provision of opening and closing by the adjustment of a counterweight is provided on top of each set of cupola.

IV. A motor-actuated butterfly valve is provided in the individual duct of each cupola, joining with the header near it. The valve of the concerned cupola under operation is normally kept open.

V. Ducting : Necessary ducting fabricated from five mm thick M.S plate has been provided from top portion of the cupola to the inlet of cyclones and from the outlet of the cyclones through the ID fan to the chimney for each of the GCPs.

VI. High performance cyclones : The gas cleaning system consists of high-performance cyclones operating in parallel. The number of cyclones provided, which incidentally is dependent upon the volume of flue gas to be handled, varied between four to eight. As the dust size <20 microns is only 5 wt% in the flue gas, G value $\simeq$ 45 has been conveniently adhered to in the design of all the above sets of cyclones with very satisfactory end result.

VII. ID fan : One number ID fan has been provided for individual GCP. The fan is of single inlet type with backward curved vane and is coupled with a direct driven motor. The relevant performance parameters like suction pressure, delivery pressure, fan efficiency etc of the selected fan correspond to the stringent system requirement..

VIII. Chimney : One number chimney has been provided for individual GCP. It has a height of 30m and is made from steel plates of various thickness. It is provided with working platforms and sampling port as per CPCB norms

IX. Dust disposal system : Dust from the cyclones is entrapped in the cyclone hopper. A rotary airlock valve (RAV) which is of robust design suitable for intermittent operation with geared motor drive is provided at the bottom of the hopper. Canvas chute is provided at the bottom of the RAV to keep the secondary emission to the minimum. Provision has been made for final collection of dust by Dumpers and disposing the same at a suitable place inside the works.

INSTALLATION OF THREE GAS CLEANING PLANTS

The installation in the above three plants was carried out based on the design/ drawings prepared by NML scientists. For the site activities , reliable contractors were engaged. Fabrication was mostly done outside at various workshops. At site, the components were assembled, welded and erected.

Main equipment/ machinery of an individual GCP were:

i) Cyclone Assembly

ii) Hopper

iii) Rotary Airlock Valve

iv) ID fan with motor

v) Chimney

These items were erected on civil foundations or steel structures depending upon the process requirement and connected by ducts to the cupolas.

Major activities during the installation were:

A) Civil and structural work
B) Mechanical Fabrication/ Erection
C) Painting
D) Electrical work
E) Instrumentation Work

TRIAL RUN AND COMMISSIONING

Once the installation was completed, pre-commissioning activities were started in each plant. After these activities were successfully executed, trial run of individual plant was performed. Two types of trial runs were carried out in each plant:

Cold Trial Run

In this type of trial run, hot flue gas from the cupola was NOT inducted in the GCP. Instead the butterfly Valve connected to the cupola not under operation was kept fully open.

Hot Trial Run

Once the cold trial run was successfully completed, the cupola which is under operation was gradually brought in tandem with the GCP.

Commissioning

Pre-commissioning activities, cold trial run and hot trial run were carried out separately for all the three Gas cleaning plants. All the GCPs were accepted as COMMISSIONED when aforesaid activities were successfully carried out and SPM level brought down below the CPCB norm which was the main pre-requisite for acceptance of these plants.

TEST RESULT

The sampling for testing of SPM level in the three plants was carried out through the sampling port specially provided on chimney at operating platform level easily accessible by staircase.

The summarised test results of SPM level measured in the three plants are given below :

Table 2 : SPM load before and after gas cleaning

Plant No.	SPM load before gas cleaning	SPM load after gas cleaning
1	1500 mg/Nm^3	i) 144mg/Nm^3 ii) 86mg/ Nm^3
2	1800mg/ Nm^3	i) 72 mg/ Nm^3 ii) 99mg/ Nm^3
3	1800-2000mg/ Nm^3	i) 73mg/ Nm^3 ii) 87mg/ nm^3

CONCLUSION

NML-designed gas cleaning system is dry type and therefore cheaper and cost effective. Each module of the GCP has less weight and fewer capital equipment. It has been expressed in several fora that cyclone alone cannot bring down the SPM level below 150mg/ Nm^3. However, with successful running of the dry type GCPs the doubts have been cleared. Moreover as no water input is necessary, this system will be specially suited for foundries located in water- scarcity prone area.

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